SCIENCE FOCUS 科言

Issue 007, 2016

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2015 年度邵逸夫生命科學與醫學獎 得主 –
邦妮·巴斯勒教授和彼德·格林伯格教授

School of Science 理學院

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

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Message from the Editor-in-Chief 主編話語

Dear Readers,

With the anticipation to the arrival of a spring full of promise (and I daresay, plenty of rain), we have a plethora of science events lined up for you. In this issue of Science Focus, find out the science behind human screams, read about what it is like to be in the quietest room on Earth and learn how bacteria communicate among themselves.

Make sure you send in your articles to our next round of Science Focus Article Submission Competition! The newest deadline is on **April 11**. To get your article published in the 8th issue of the magazine, please send your article to us before that date.

So in the spirit of spring's renewal, brush up on your scientific knowledge, get proactive with your education and best of luck to the upcoming DSE exam period!

Yours faithfully,

Prof. Yung Hou Wong
Editor-in-Chief

親愛的讀者：

我們在期待充滿希望(而且，想必是雨水充沛)的春天來臨時，為你安排了一系列的科學活動。在本期「科言」，你會發現人類尖叫聲背後的科學理論，了解身處世上最安靜的房間的感覺，和知道細菌如何彼此溝通。

還有，謹記投稿新一輪「科言」徵文比賽，截止日期是 **4 月 11 日**。若你想有機會在本刊第八期發表文章，請在該日期之前遞交稿件。

春天萬象更新，也是好好溫習科學知識，積極投入學習時。在此預祝你們 DSE 考試順利！

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敬上

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WHAT'S HAPPENING IN HONG KONG? 香港科學活動

By David Iu 姚誠鵠

Boundless is the ocean of knowledge. The pursuit of truth is an endless journey. Don't miss out on these eye-opening events!

Hong Kong SciFest 2016

The annual science festival is back! Indulge yourself in the kaleidoscope of science through drama shows, workshops and seminars. Held from **Mar 3** to **Mar 18**, the event includes Science Alive 2016, the FameLab contest, Interactive Lectures, and more! The carnival, with a focus on "Impossible to Possible" this year, will inspire you with the intricacies of the things we can see and those we cannot. Should you be interested, please visit their website at: *http://www.britishcouncil.hk/en/programmes/education/science/science-alive*

17th Asian Physics Olympiad (APhO 2016)

The prestigious Asian Physics Olympiad will be held for the first time in Hong Kong this year! The Hong Kong University of Science and Technology will welcome participants from all over Asia between **May 1** to **May 9**. A premier physics competition for pre-university students, APhO 2016 invites over 200 young geniuses from 27 countries/regions, who will take on the challenges of advanced theoretical and experimental physics, engage in cultural and scientific exchange, and build international friendships. Want to follow their activities? Stay tuned at *http://apho2016.ust.hk/* and *https://www.facebook.com/apho2016/* .

Hoi Ha Wan Marine Park and WWF Hoi Ha Marine Life Centre

Catch a break from the *stress and tension* of schoolwork at this pristine paradise! Hoi Ha Wan is home to over 60 types of hard coral and 120 species of coral fish, and arguably the most famous marine park in Hong Kong in terms of species diversity and richness. While the cold weather is perhaps not the most ideal season for snorkelling or kayaking, you can still join the education programmes offered at the WWF Hoi Ha Marine Life Centre, which features on-site ecological studies and a glass-bottomed boat trip around the picturesque cove. Do not hesitate to contact your school to arrange a visit!

http://www.wwf.org.hk/en/whatwedo/education/schoolsoutreach/secondaryprog/

學海無涯，渴望追求真理的你豈可錯過下列開闊眼界之科學活動？

2016香港科學節

一年一度的香港科學節回來啦！提供讓人目不暇給的科學劇場、工作坊和研討會等等科學活動。其中由2016年**3月5至18日**舉行的「活的科學」，將以「從不可能到可能」作主題，設有「科學一叮」比賽、互動講座等，介紹看得見和看不見的奧妙，啓發你探索科學的樂趣。欲要了解更多相關資訊，請瀏覽：*https://www.britishcouncil.hk/programmes/education/science/science-alive*

第十七屆亞洲物理奧林匹克 (APhO 2016)

這項學界盛事首次在香港舉行。香港科技大學將於2016年**5月1至9日**，接待來自亞洲各地的選手。APhO是中學生的超級物理比賽，超過200名來自亞洲27個國家或地區的年輕物理才俊，將獲邀在此挑戰高階的理論和實驗物理學難題。

他們還會參與文化和科學交流，建立跨國友誼。若想得知更多詳情，可以瀏覽網址：*http://apho2016.ust.hk/*和*https://www.facebook.com/apho2016/*

海下灣海岸公園及世界自然基金會海下灣海洋生物中心

在這質樸的淨土，你可以把學業壓力拋諸腦後！海下灣是超過60種石珊瑚和逾120種珊瑚魚的棲息地，就物種多樣性和豐富度來講，可以說是全港最有名的海岸公園。凜冬時節，未必適合浮潛或划艇等活動，但你還是可以參與海下灣海洋生物中心舉辦的教育活動，包括實地生態研習和乘坐玻璃底船考察珊瑚。同學可經由校方安排參觀：*http://www.wwf.org.hk/whatwedo/education/schoolsoutreach/secondaryprog/*

Guide to US University Summer Courses

Each year, many US universities open their doors to secondary school students for summer courses. Students can enroll in university level courses, preview college life and make lasting friendships from all around the world. Check out some of the universities below for more detailed information!

每年，美國許多大學都會敞開大門，歡迎中學生報讀暑期課程。學生可以修讀大學課程，淺嘗大學生活，結交來自世界各地的同學。詳情可參考下列大學介紹。

Duke University Summer College for High School Students

Applications Begin: December 1

Deadline: April 15, 2016

Programme Duration: July 10 - August 5

Further Information:

Students who attend the Duke University Summer College for High School Students will focus the daytime hours on one intensive Duke University undergraduate course, which will be recorded as academic credit on an official Duke University transcript. Students should feel free to explore more about Duke in the evening.

Duke University Summer College offers courses in different disciplines: Human and Environment; Truths and Lies about GMOs; Microbes and the World Around Us; Game Theory; Primate Conservation; Big Questions in Physics; Social Psychology and more.

Please visit: *http://summersession.duke.edu/high-school-students/summer-college-for-high-school-students*

English Language Proficiency: The minimum required scores are 90 for the Internet-based TOEFL, 575 for the Paper-Based TOEFL and 7.0 for IELTS. A more competitive score would be 100 and 600 for the Internet-based TOEFL and Paper-based TOEFL, respectively.

杜克大學高中生暑期課程

申請日期：2015年12月1日開始接受報名

截止報名：2016年4月15日

課程時間：2016年7月10日至8月5日

其它：

獲取錄的同學日間將專注修讀一個杜克大學的本科密集課程，所得學分會列入大學成績單。課餘時候可自由探索，感受杜克大學的校園氣氛。

杜克大學暑期課程提供不同範疇的科目：人類與環境、基因改造生物的真相與謊言、我們周遭的微生物世界、博奕論、靈長類保育、物理學大問題、社會心理學等等。

相關網址：

http://summersession.duke.edu/high-school-students/summer-college-for-high-school-students

英語能力要求：

最低分數須達：託福網路測驗90分，託福紙筆測驗575，雅思7.0。較具競爭力的分數：託福網路測驗100分，託福紙筆測驗600。

美國大學暑期課程指南

By Long Him Cheung 張朗謙

Harvard Summer School

Applications Begin: Mid-November

Deadline: April 18 2016

Programme Duration: June 18 - August 6

Further Information:

You'll study with Harvard's faculty and visiting scholars, and earn college credit you may transfer to your chosen university. Secondary School Programme classes are taught by Harvard faculty who teach the same courses to Harvard College students during the academic year or by visiting scholars who hail from renowned institutions around the world. Courses are held in the mornings, afternoons, or evenings. The programme spans seven weeks, and most courses meet for six weeks, with a final exam, paper, or project during the seventh week.

The Summer School offers over 200 courses in over 60 subjects; some of the most popular topic areas include Language Arts, Maths, Engineering, Premedicine, Science, Social Science, and Technology.

Please visit: *http://www.summer.harvard.edu/programs/secondary-school-program/admission-getting-started*

哈佛暑期大學

申請日期：2015年11月中開始接受報名

截止報名：2016年4月18日

課程時間：2016年6月18日至8月6日

其它：

由哈佛的教職員及來自世界各地知名學府的客席學者授課，所得學分可轉移到同學選擇的大學。早、午、晚都編排了科目。課程長達七週，上課時間一般為六週，最後一週是考試或提交論文報告。

該暑期課程提供涵蓋60多個領域的200個科目，較為熱門的科目包括：語言藝術、數學、工程、醫學預科、科學、社會科學和科技。

相關網址：

http://www.summer.harvard.edu/programs/secondary-school-program/admission-getting-started

Stanford High School Summer College

Applications Begin: Now

Deadline: ***International Students Who Require a Stanford-Sponsored I-20:*** Friday, April 1, otherwise, May 27

Programme Duration: June 18 - August 14

Further information:

Stanford High School Summer College offers more than 145 courses for students to explore, collaborate and challenge themselves. A wide variety of courses are offered, covering broad topics including: Biochemistry, Environmental Science, Water Science, Engineering, Decision Making, Astrophysics etc.

Besides studying advanced courses, Stanford High School Summer College provides fruitful residential life for students with facilities such as swimming pools, tennis courts, gym and other activities facilities for students to utilise. The campus even includes a karaoke, land for tree-planting, service workshops, residential hall programmes and outreach.

Please visit: *https://summercollege.stanford.edu/apply*

史丹佛大學高中暑期學院

申請日期：現已接受報名

截止報名：***須由大學發出I-20的國際學生***，截止日期為2016年4月1日；其它申請的截止日期是5月27日。

課程時間：2016年6月18日至8月14日

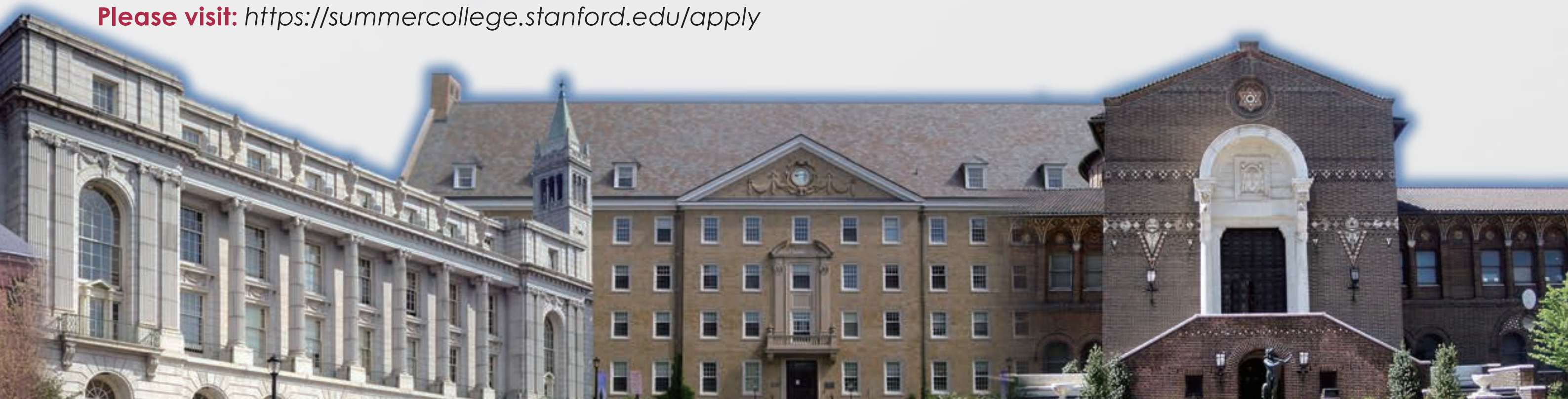
其它：

史丹佛大學高中暑期學院提供超過145個課程，讓同學可以不斷探索、與別人協作及挑戰自己。課程覆蓋範圍廣泛，包括：生物化學、環境科學、水科學、工程、決策、天體物理等。

除了高階課程，史丹佛大學高中暑期學院還會為同學提供充實的住宿生活，有大量設施如游泳池、網球場、健身室等供學生使用。校園甚至設有娛樂及植樹空間，又會組織服務工作坊、宿舍活動及外展機會。

相關網址：

https://summercollege.stanford.edu/apply



ARTIFICIAL PHOTOSYNTHESIS

綠導能媒：人工光合作用

By David Iu 姚誠鵠

This article may be useful as supplementary reading for biology classes, based on the DSE syllabus.
根據生物科文憑試課程剛要，本文或可作為有用的補充讀物。

Staggering population growth and industrialisation in the past century have led to a tremendous increase in energy expenditure, resulting in a series of energy crises and irreversible environmental repercussions. To address these growing energy demands, much focus has been placed on developing technology that can harness renewable energy sources. Scientists are now closer than ever to constructing a system with the ability to transform water into fuel using solar energy, which may just hold the key to offsetting carbon emissions and quenching our thirst for energy. For example, an artificial leaf that is able to carry out photosynthesis is one of such projects.

Solar energy is an unexplored natural resource largely untapped until recently. Current solar photovoltaic cell technology possesses crippling limitations that prevent widespread commercialisation, including low efficiency and intermittency. Plants, on the other hand, have been harnessing energy from the sun for billions of years, using sunlight to produce usable glucose from carbon dioxide and water in a well-known process called photosynthesis. Artificial photosynthesis that mimics this clever natural process can theoretically create a storable supply of energy and electricity. Instead of glucose, however, the desired end product is liquid hydrogen to be used as fuel that is stored in a fuel cell. This can be achieved by splitting water molecules for the isolation of hydrogen.

By integrating biology and nanoscience, researchers at the University of California at Berkeley, have discovered a novel approach to water-splitting and carbon fixation, utilising a common bacterium as the biocatalyst [1]. Photosynthesis is comprised of two major steps: the photochemical reactions and the light-independent carbon fixation. In most autotrophs (organisms that are capable of producing their own food using surrounding inorganic materials), light is absorbed by chlorophyll in the photosystems of chloroplasts and water is broken down into hydrogen ions, oxygen ions and electrons. The released electrons have multiple functions. It can be used to reduce the photo-oxidised chlorophyll. Alternatively, it can move along the electron transport chain and gradually release energy in the process by reducing NADP+ into NADPH to produce sugar by fixing CO_2 molecules in the light-independent reactions.

Artificial photosynthesis manipulates natural photosynthesis in a way that biochemical reactions will harness and store solar energy in the chemical bonds by intercepting electrons produced in the photosystems. This method employs photosynthesisers such as chlorophyll in solar cells. Recently, researchers at Massachusetts Institute of

Technology (MIT) have successfully extracted the entire electron transport chain and transplanted it onto a thin-film solar cell [2].

Unfortunately, perfecting artificial photosynthesis is still in its nascent stages. Its principle limitation is efficiency. At 5% efficiency, the cost of which to operate this technology is nowhere near comparable with that of electricity generated from the grid. Biological catalysts are also expensive, adding to the total cost of the system [3].

To address these issues, researchers at the University of California at Berkeley suggested an alternative approach. Instead of producing electrons and hydrogen gas, the group hybridised the anaerobic bacteria *Methanosarcina barkeri* using nano nickel sulphide (NiS) catalysts to convert H_2 and CO_2 to methane and oxygen (or butanol in a similar experiment). Methane is the primary component of natural gas, whereas butanol can be found in petrol. Both products can be used to produce liquid fuels that can be stored and distributed through existing energy infrastructure.

According to experts at the Berkeley Lab, their system has the potential to fundamentally change the chemical and oil industry to produce chemicals and fuels renewably as an alternative to oil mining. The advent of artificial photosynthesis could be the answer for the long-standing issue of air pollution – for once, we can manipulate the forces of nature toward greener pastures.

在過去一個世紀，人口增長和工業化幅度驚人，使得能源消耗大幅攀升，導致了一連串的能源危機，更對環境做成不可逆轉的影響。為了滿足不斷增長的能源需求，已有大量精力投放在開發可再生能源技術。科學家們很快就可以構建不同系統，利用太陽能將水轉化為燃料，從而抵銷碳排放，並滿足我們對能源的渴求。其中一個設計就是進行光合作用的人工樹葉。

不久之前，太陽能還是一種未開發的自然資源。現有的太陽能光伏電池技術有很多局限，包括低效率和間歇性發電等，所以不能大規模商業化。另一方面，植物早在數十億年前，就開始以我們熟悉的光合作用，利用陽光將二氧化碳和水製成有用的葡萄糖。人工光合作用模仿這巧妙的自然過程，理論上應能提供可儲能源和電力。不過我們想要的最終產品不是葡萄糖，而是儲存在燃料電池的液態氫。這可以靠分解水分子而獲得。

美國加州大學伯克萊分校的研究人員結合生物學和納米科學，開發了一種新方法，以常見的細菌作為生物催化劑，分解水和固定二氧化碳[1]。光合作用有兩個主要步驟:光化反應和不需要光的固碳作用。大多數的自養生物(指能夠利用無機物合成自身食物的生物)，以葉綠體光系統的葉綠素吸收光能，然後把水分解成氫離子、氧氣和電子。放出的電子可以還原被光氧化的葉綠素;又或者在電子傳遞鏈中遊走，將NADP+ 還原成 NADPH，逐漸釋出能量，之後用於固定二氧化碳生成糖分子。

人工光合作用的做法是操控自然光合作用，通過生化反應攔截在光系統產生的電子，然後將太陽能儲存在化學鍵中，以待後用。這種方法須要將葉綠素之類的光合作用系統加進太陽能電池中。最近，美國麻省理工學院的研究人員就成功地把整個電子傳遞鏈移植到薄膜太陽能電池[2]。

不幸地，人工光合作用仍處於起步階段，前方尚有漫漫長路。最大的限制在於效率:人工光合作用迄今仍未突破百分之五的光電流轉換效率，操作成本與傳統生產模式無法相比。此外，生物催化劑價格高昂，也增加了系統的成本[3]。

為了掃平上述障礙，柏克萊加大的研究人員放下了生產電子和氫氣的設計，改用厭氧細菌巴氏甲烷八疊球菌和納米硫化鎳，成功地把氫氣和二氧化碳轉化成甲烷和氧氣(在類似的實驗中，亦可得到丁醇)。甲烷是天然氣的主要成分，丁醇則可以在汽油中找到。兩者均可用作生產液體燃料，然後通過現成的基礎設施儲存和運輸。

伯克萊實驗室的專家認為他們的系統可以從根本改變化學和石油工業，生產可再生的化學品和燃料，以替代石油開採。展望將來，人工光合作用的崛起，可能會驅散霧霾，解決空氣污染這個長期問題。這一次，人類終於能運用大自然的力量讓綠色的地球重生!

References

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IN PURSUIT OF SILENCE

完美寧靜空間

By Thomas Lee 李浩賢

The tranquility of libraries is no match for the anechoic chamber (echo and reverberation free) at Minnesota's Orfields Laboratory. Measuring at -9.4 dB (decibles), the room made its mark in the Guinness Book of Records as the "quietest room on Earth" and is insulated to any external sounds by means of suspension and sound absorbing material. To put that into perspective, the human ear stops detecting sound at 0 dB. In fact, the lack of noise is so intense and derailing that reputedly, no one has ever been in the room for longer than 45 minutes. Recently, a finer sound absorbing device was constructed, giving an equally promising performance with applications beyond sound absorption.

As it turns out, too much peace and quiet isn't all it's cracked up to be. The muted environment in the anechoic chamber amplifies the feeling of the tiniest sounds – from heartbeats to intestinal noises - bringing disorientating acute awareness to sounds that would otherwise not be heard. Imagine suddenly being able to hear your own lungs or the rush of your blood pumping. The chamber comes equipped with a chair, because even standing is apparently too disorientating as your ears subconsciously use surrounding sounds to balance.

Sound waves are essentially vibrations of an object and can be transmitted through air, liquids or solids. Waves are propagated by subsequent

美國明尼蘇達州的Orfields「零回音室」內寧靜無比。房間通過獨特設計和吸音物料，隔絕了外界的一切聲音，室內音量只錄得–9.4分貝，贏得健力士世界紀錄中的「地球上最安靜的房間」的稱號。要知道人類耳朵所能聽到的最低音量是0分貝。這無聲環境讓人無法忍受及產生幻覺。據說，從來沒有人能在房間內逗留超過45分鐘。最近有科學家製造了一個更精細的吸音裝置，具備同樣性能且可以應用在其它方面。

過於寧靜並不是想像中的好。在「零回音室」的靜音環境中，心跳和腸臑動等微細聲音都會被放大，清楚感應到平常聽不見的聲音，令人不知所措。想像一下突然能夠聽見自己的呼吸和血液泵動的聲音時，你會有甚麼感覺？耳朵慣常是以周圍的聲音來保持平衡，在這裏光是站立也會迷失方向，所以房間內設有椅子。

聲波本質上是物件的振動，可以通過氣體、液體或固體來傳送。聲波傳播依靠分子間的碰撞，這樣解釋了聲音為何不能在真空傳播。「零回音室」是以一層層厚厚的混凝土和鋼材阻隔外來的聲音，但真正消除迴聲或混響的關鍵，是內裏交叉覆蓋著有吸音功能的梯度折射率纖維。發泡材料和海綿也常作此用途，但它們既佔空間又不耐用。

去年，香港科技大學的研究員於《自然—材料學》發表論文，介紹一種可以完全吸收聲波的聲學超表面。薄薄的超

molecular collisions, which is why sound cannot be transmitted in a vacuum in the absence of particles. An anechoic chamber is insulated by thick concrete and steel to prevent external sound, but the real magic occurs internally, where sound absorbing, fibrous and gradient-index materials are lined in a cross-hatched fashion to eliminate echo or reverberation. Foam wedges and sponges are often used for this purpose, but they are space-consuming and do not last very long.

In a paper published in *Nature Materials* last year, scientists at the HKUST constructed an acoustic metasurface that can completely absorb acoustic waves. A thin, three-layer metasurface unit cell is composed of a decorated membrane resonator (DMR), a reflective backing and a sealed sulphur hexafluoride (SF_6) gas layer sandwiched in between. DMR is an elastic membrane, with a platelet located at the centre to increase acoustic absorption. The metasurface exhibits resonance at audible frequencies (e.g., 152 Hz in the reported experiment). When the system matches the impedance of airborne sound waves, it achieves near perfect sound absorption and zero reflection [1].

There are two significances over this invention – first, the metasurface is an excellent absorber of acoustic energy, and second, the system does not reflect waves when absorbing a particular sound wave. A further improvement to the device would be to tune the metasurface into absorbing a range of sound waves by making more sophisticated decorations on the membrane to provide profuse resonances in variant frequencies.

The hybrid resonant acoustic metasurface is a likely energy harvester, particularly if the metasurface is installed in a noisy environment. When resonance is present, energy is concentrated on the membrane. Researchers coupled neodymium magnets to the membrane through copper wires so that the whole system behaves like an inverse speaker. While the copper wires move in the magnetic fields of neodymium magnets, according to Faraday's law, the noise energy on the membrane will be converted into electrical current.

表面結構單元由三層材料組成：裝飾膜諧振器（DMR）、反射背板、和之間密封的六氟化硫氣體層。DMR是一片彈性膜，其中心有小板以增強隔音功能。超表面系統可在聽覺頻率範圍內(如測試所用的152Hz)產生共振。當系統與空氣中的聲波阻抗匹配時，就會達到近乎完美的吸音和零反射的效果[1]。

這項發明的重要性有兩方面：1) 超表面是優良的聲能吸收器；2) 系統吸收特定聲波時不會產生反射。進一步的改良，是要在膜上加上更複雜的配件，以提供不同的共振頻率，從而調節可被吸收的聲波範圍。

研究所得的混合共振聲學超表面，可以成為能量採集器，尤其是在嘈雜的環境中。共振產生時，能量集中在膜內。研究人員以銅線將釹磁鐵與膜連接起來，整個系統就像一個逆揚聲器。當銅線按法拉第定律在釹磁鐵的磁場內運作時，膜上的聲能便會轉化為電力。

Anechoic Chamber
零回音室

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The Chernobyl Aftermath: Resetting an Ecosystem

By Rinaldi Gotama 李嘉德

April 26, 1986 was a relatively typical day for the citizens of Pripyat, a town specifically created to house nuclear experts and workers of the Chernobyl Nuclear Power Plant located in, what is now, Ukraine. Due to a flawed reactor design as well as human error, Chernobyl's reactor number four exploded, setting a record as the worst nuclear disaster in history. To put this into perspective, the accident released 400 times more radiation than the Hiroshima atomic bomb did in 1945. People in the immediate vicinity received an estimated 350 millisieverts (mSv) of radiation before being evacuated from the city. This is equivalent to 3500 chest X-rays in a short period of time, and around 17 times the fatal dose [1]. Although an emergency concrete sarcophagus was erected around the offending reactor to curb the release of radiation, the impact of the explosion to the surrounding ecosystem and community is perennial.

More than five million people of Belarus, Russia and Ukraine were affected as a result of the radioactive explosion that contaminated the surrounding environment and led to the relocation of almost 300,000 people to safer areas [2]. In a 10-year Chernobyl aftermath report, it was found that the release of short-lived radioiodines (iodine-131 has a half-life of 8 days) into produce caused a significant increase in the number of cases of thyroid cancer, particularly among children who consumed contaminated milk. Radiocaesium destroyed agricultural grounds and forests in the first few weeks of the explosion and an increase in birth defects among farm animals was reported. However, the same investigation indicated that aside from thyroid cancer, no long term health impact from the explosion was detected. In fact, any detrimental environmental impacts were also largely transient [1].

On the contrary, damage from the radioactive expulsion has been observed to be on a scale much smaller than originally projected, given the enormity of the accident. A quarter of a century in the aftermath, species in the vicinity of what is known as the Chernobyl exclusion zone have astonishingly flourished. The purpose of this zone is to inhibit access to severely radiologically contaminated areas for safety reasons. Yet, the diversity of these species has increased to a record number. It is likely that the removal of their biggest predators, humans, have led to this observation [2]. As people left, activities that harm biodiversity, such as agriculture and industry, vanished with them – allowing plants and animals to naturally expand their habitats.

What does this say about the effect of the nuclear accident on wildlife? According to Jim Smith at the University of Portsmouth in the U.K., "This doesn't mean radiation is good for wildlife, just that the effects of human habitation, including hunting, farming, and forestry, are a lot worse" [3]. While wildlife has apparently burgeoned healthily in the years following the accident, it does not suggest that the Chernobyl exclusion zone is safe for prolonged human exposure or that the area has returned to 'normal'. It would also be worthwhile to investigate genetic mutations over generations of species that may have been engendered by the lasting radiation in contaminated areas.

Did you know

Major radioactive substances released at Chernobyl included iodine-131, caesium-137, strontium-90 and plutonium-241. While iodine-131 decays rapidly with a half-life of about 8 days, caesium-137 and strontium-90 approximately require 30 decades to be completely gone from the environment.

再看切爾諾貝利：生態系統重構

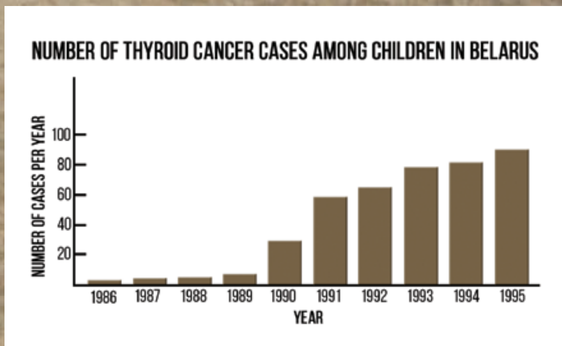
This article may be useful as supplementary reading for physics classes, based on the DSE syllabus.
根據物理課文憑試課程，本文或可作為有用的補充讀物。

1986年4月26日，本是現今烏克蘭境內普裡彼特鎮平靜的一天。這個小鎮是專為切爾諾貝利核電站的專家和工人而建。由於核反應堆設計問題以及人為錯誤，切爾諾貝利核電站四號反應堆發生爆炸，創下了歷史紀錄上最嚴重的核災難。這事故釋放的輻射量要比1945年的廣島原子彈還要高400倍。附近居民在疏散前接受了近350毫西弗（mSv）的輻射量，相當於在短時間內接受3,500次的胸部X光檢查，也是致命劑量的17倍 [1]。儘管當時立即在四號反應堆築起混凝土棺以遏止輻射釋放，爆炸對周圍的生態系統和社區已造成持久的影響。

超過500多萬白俄羅斯、俄羅斯和烏克蘭人因切爾諾貝利事故而受到影響。爆炸污染了周邊的環境，導致近30萬人要搬遷到較安全的地帶 [2]。有報告總結切爾諾貝利事故後十年的遺害，發現短半衰期放射性碘（iodine-131的半衰期為8天）擴散到農產品，以致甲狀腺癌病例的數量顯著增加，尤其是在食用受污染牛奶的兒童中。在爆炸後最初的幾個星期中，放射性銫摧毀了農地和森林，有出生缺陷的農場動物也多了。不過，報告同時指出除了甲狀腺癌之外，並沒有察覺爆炸對健康造成長期影響。事實上，大部分對環境不利的影響都是暫時性的 [1]。

相反，就事故的嚴重性而言，這場放射性爆炸所造成的傷害遠遠小於原先預計的規模。四分一世紀過去了，在被稱為「切爾諾貝利隔離區」附近的物種卻意外地繁茂。成立隔離區原是出於安全考慮，不讓進入受嚴重輻射污染的地方。然而，物種多樣性卻升至紀錄高位，出現這種情況可能是因為牠們最大的天敵──人類──消失了 [2]。人們離開後，危害生物多樣性的活動，如農業和工業，也隨之而消失，動植物得以自然地擴大牠們的棲息地。

到底核事故對野生動物的影響是怎樣？英國朴茨茅斯大學的吉姆史密斯認為：「這並不意味著輻射對野生動物有利，只是人類的棲息活動包括狩獵、農耕和林業，所造成的損傷和影響更惡劣」[3]。雖然多年來，野生動物似乎可以在隔離區健康地生息繁衍，並不代表該區已恢復"正常"，適合人類長期逗留。另一方面，區內生物長期受輻射影響，跟蹤研究這些物種多代的基因突變情況，將會提供重要資訊。



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你知道嗎

切爾諾貝利所釋放的主要放射性物質包括放射性碘（iodine-131）、放射性銫 (caesium-137)、放射性鍶（strontium-90）和放射性鈈（plutonium-241）。放射性碘的半衰期較短，約8天，但銫和鍶的衰變需要大約30年的時間。

The Banana Peel Trap
香蕉皮陷阱

By Long Him Cheung 張朗謙

This article may be useful as supplementary reading for physics classes, based on the DSE syllabus.
根據物理課文憑試課程，本文或可作為有用的補充讀物。

Banana skins, a slapstick staple and Elmer Fudd's worst nightmare. We've all watched with anticipatory amusement at the impending doom of a banana skin trap for the unwary cartoon antagonist – and we all know what happens next. The banana skin possesses deep-rooted entrenchment in our psychology as a weapon of mass slippage, but its history as a hazardous booby trap actually began in the mid-19th century by American authorities to avoid street littering, bringing us to question whether there is any inkling of truth in this centuries' old belief. Fortunately, Japanese scientists Mabuchi and his group have performed the Ig Nobel Prize winning science necessary to bust this unusual myth once and for all.

Using Cavendish bananas, the researchers placed peels on a linoleum plate with the inner

香蕉皮是經典喜劇的武器，當我們看到它的出現，都會不自覺地期待著不幸的角色出現，然後……哎呀！香蕉皮在我們的意識中根深蒂固地與滑倒掛鉤，然而這個"常識"其實是19世紀中期美國當局為了防止人們隨地拋垃圾而提出的。究竟這個百年概念孰真孰假?日本學者馬淵與其科研團隊破解了這個迷思，並獲得了搞笑諾貝爾獎的榮譽。

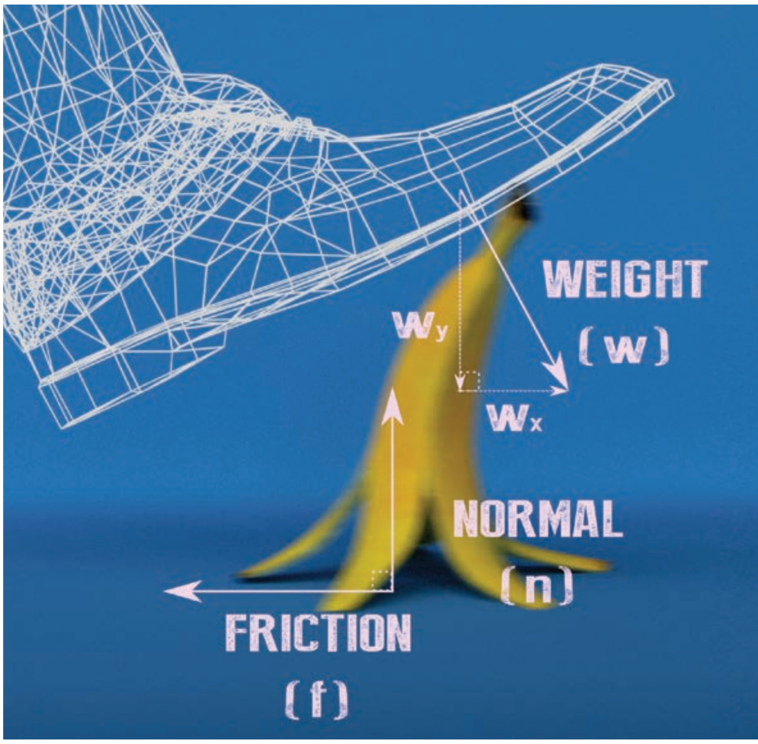
科研人員把香芽蕉的皮內層朝下放在油氈板上，之後模擬踩蕉皮的情況，鞋底與之接觸並向前滑動擦過蕉皮。固定在油氈板下的力傳感器便會測量多方向的力度，從而計算出蕉皮對應油氈板的摩擦系數。摩擦系數愈小就意味著表面愈滑。經過五次實驗，用了十二根香蕉，團隊發現蕉皮把表面的摩擦力降低了80%，摩擦系數只剩下0.066，比一般表面要低得多，可與潤滑過的表面比擬(0.1)。簡單點說，踩蕉皮就跟溜冰差不多，這也證明了香蕉皮就如眾所週知是滑的。

peel face down. The slipping scenario was then simulated by rubbing the peel with a forward sliding motion of the sole of a shoe upon contact. A force transducer was secured under the linoleum plate to measure the magnitude of the forces in the x and y directions to determine the coefficient of friction (μ) between the contact surface and the ground. A lower coefficient of friction implies that the surface is more slippery. The experiment was repeated five times with twelve banana skins. It turns out that the addition of a banana skin dramatically reduced the friction between the shoe and the surface by up to 80%, with the resulting μ to be at about 0.066 – a value that is significantly lower than general surfaces and comparable to well-lubricated surfaces (0.1). To put this into perspective, the banana peel was found to be as slippery as skating on ice, validating the general consensus that banana skins are indeed slippery.

The lubricating property of the banana skin is due to its branches of follicular gel, composed of polysaccharides and proteins, held together by the skin. When the skin is compressed during slippage, the cellulose membranes of the follicles are crushed, releasing the follicle gel and creating a homogenous solution. This solution forms a lubricating fluid film between the shoe and the surface that decreases friction.

While this experiment simulates the scenario well, it does not take into account the age of the banana skin. For instance, one is less likely to slip when a banana skin is dried or when the surface is rough. A dry banana skin has lower water content, and hence a lower volume of follicular gel. Furthermore, if the surface of the floor is too rough, its irregularity disrupts the layer of the fluid film and increases the coefficient of friction. It also does not take into account the difference between static and dynamic friction. The above experimental set-up measures the dynamic friction between the inside of the banana peel and the surface. In a real life scenario, when someone steps on the peel, the friction involved is static. It is known that static friction can be larger than dynamic friction, thus the danger of banana peels may be overestimated in this experiment.

So there you have it. The notion of slippery banana skins indeed holds some truth. Aside from this being a funny shower thought though, experts say that the research has the noble potential to bring about new types of lubricants or provide insight into bioengineering lubricating joints for arthritis.



蕉皮的潤滑性歸功於所含的囊泡凝膠。凝膠由多糖和蛋白質組成，平時鎖於蕉皮內。當蕉皮受壓時，囊泡的纖維素膜破裂，凝膠流出成為均勻溶液，在鞋與地面之間形成一層流體潤滑膜，減低摩擦力。

雖然這個實驗很好地模擬了踩蕉皮的情境，卻沒有考慮到蕉皮的新舊程度。比如說，蕉皮太乾的話，囊泡多糖凝膠的體積便會因水份不足而減少，潤滑效果自然就不明顯。此外，若果地面過於粗糙，流體薄膜受到破壞，潤滑功能也未必能發揮。另外，這個實驗並未考慮靜態和動態摩擦之別。實驗量度的是蕉皮內側和接觸面之間的動態摩擦。可是在現實中，我們踩蕉皮時所涉及的摩擦是靜態的，而靜態摩擦是可以比動態摩擦強，因此這實驗有可能高估了踩蕉皮的危險。

好了!現在大家明白踩到蕉皮會滑倒，是確有其道理!除了提供趣味小知識，專家指出這研究還有更深遠的意義，可以帶來新型的潤滑劑，亦會有助設計更潤滑的關節。

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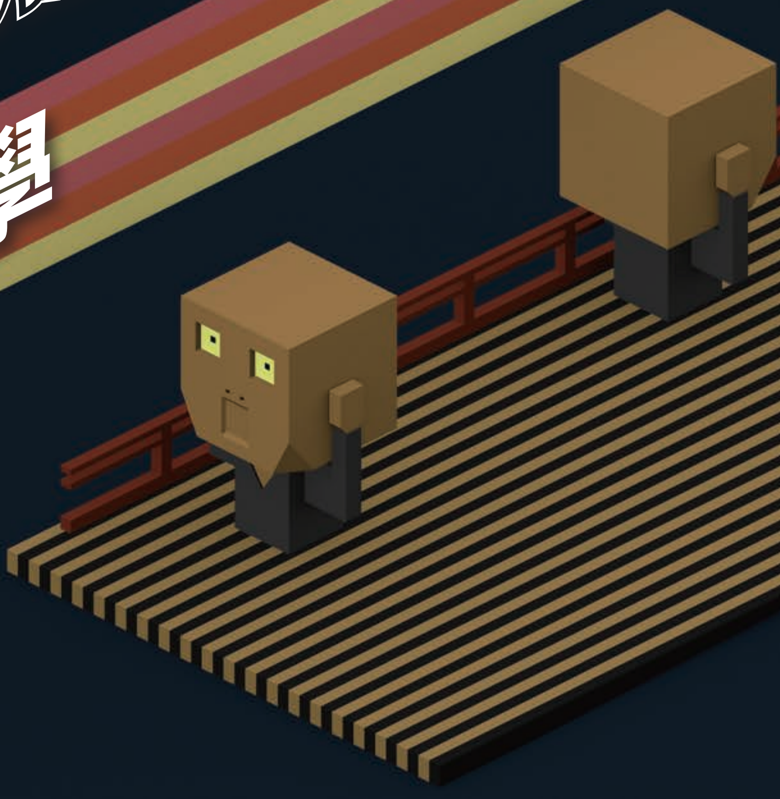
THE SCIENCE OF SCREAMS

尖叫聲的科學

by Raphaella So 蘇韋霖



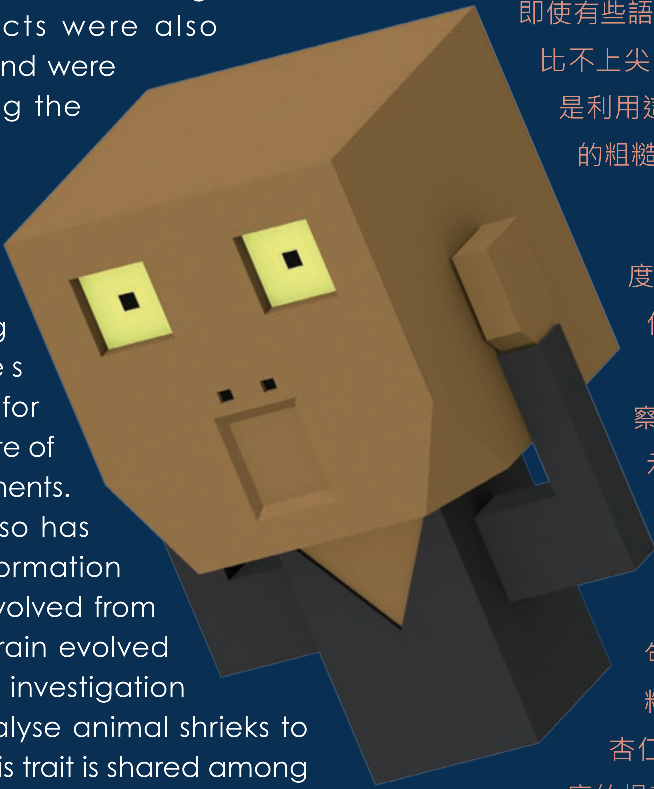
Human ears are extremely sensitive to signals for help. Shrieks or calls of distress naturally elicit immediate head turns in all directions. This evolutionarily advantageous response is easy to comprehend. If someone nearby screams, "fire", the instant response would be to run for your life and hopefully escape danger. It turns out that human screams possess a distinctive acoustic property that activates a specific centre in the brain and generates the fight-or-flight response to a perceived harmful event or threat of survival.

Our brains respond differently to various frequencies in the audio spectrum. By determining the fundamental frequency of someone's voice, we can judge their gender. Similarly, by paying attention to the slow temporal fluctuations in speech, we can decipher the tone, underlying meaning or emotion of the deliverer. To enable ourselves to respond quickly to distress signals, it would be reasonable to be able to detect distinctions between normal speech and unpleasant sounds such as screams and alarms. It turns out that sounds with rapid modulation between 15 – 300 Hz in frequency have this exact distinction. In other words, the sound fluctuates from loud to soft rapidly [1]. While conventionally thought to carry no ecological significance, this region is now identified as "roughness" and plays an important role in recognising danger.

Also known as a modulation power spectrum, roughness is the measure of the volume of sound changing over short periods of time. These fluctuations are not found elsewhere in normal speech. Compared to neutral vocalisations such as singing or speaking, the roughness component is significantly stronger in screaming. This finding also transcends spoken languages, even when some languages appear to sound more aggressive than others. Meanwhile, artificial alarms such as sirens make use of this special audio niche. Their roughness indices mimic those of natural screams, thereby allowing sirens to alert for danger.

Scientists experimented to test their hypothesis for the role of roughness in triggering the fight-or-flight response in humans. They measured the sound properties of normal sounds versus those of screams and observed MRI scans of subjects listening to screams. The results showed that low-roughness screams induced a lower fearful response from subjects; while high-roughness vocalisations (that were not necessarily screams) provoked a heightened response of fear [2]. In other words, the quality of roughness was the sole determinant between the different levels of response in fear. Additionally, the amygdala – the emotional centre in the brain – was activated in response to hearing screams. With a heightened roughness index, subjects were also observed to react faster and were more accurate in locating the source of the sound.

The unique roughness component of distress signals serves as an efficient means of alerting danger and carries evolutionary significance for humans to increase their rate of survival in adverse environments. Research into this area also has the potential to reveal information on how communication evolved from earlier times or how the brain evolved to deal with fear. A similar investigation could be extended to analyse animal shrieks to gain information on how this trait is shared among different species.



大腦可以針對各種音頻做出不同的反應。我們可以通過聲音的基頻來判斷說話者的性別。同樣地，當聲波振幅變化比較慢時，我們稍加留意就可以辨識語氣、語意或情緒。那麼，為了使自己能夠對求救信號作出快速的反應，我們理應可以區別正常語音和刺耳聲音，如尖叫聲和警報聲。的確，這類聲音的振幅變化頻率都是處於30至150 Hz之間。換句話來說，聲音在強弱間迅速波動[1]。普遍以為這個音域沒有任何特別的功能，但是最近科學家發現，這「粗糙度」區間在識別危險方面起著重大作用。

調製功率譜（modulation power spectrum）可以記錄音量在極短時間內的變化。以此方法分析日常話語，發現相比於唱歌或說話，尖叫聲的粗糙度明顯地強烈。即使有些語言聽來似乎粗獷，其粗糙度實在比不上尖叫聲。人工警報聲如警笛等，就是利用這種聲音特性，模仿天然尖叫聲的粗糙度，從而起到示警作用。

科學家們透過實驗以探索粗糙度在「戰鬥或逃跑」反應機制中的作用。他們測量了正常聲音和尖叫聲的屬性，並通過腦部掃描觀察人們對尖叫聲的反應。結果顯示，粗糙度低的尖叫聲會引起較低的恐懼反應；粗糙度高的發聲，就算不是尖叫聲，也足以激起較大的恐懼反應[2]。換句話說，恐懼反應的程度取決於粗糙度。此外，大腦的情感中樞杏仁核會被尖叫聲啟動。隨著粗糙度的提高，受試者的反應也會變得更迅速，並且可以更準確地將聲源定位。

人類的耳朵對求救信號特別敏感。任何尖叫聲或者一句「救我」，都會馬上吸引到各方的注意。其實不難理解這種反應對物種生存有利。如果附近有人叫「火災呀」，那你即時會逃生避險。原來，人類的尖叫聲有種特質，會啟動腦子裏一個部位，引發我們面對危機時的戰鬥或逃跑反應。

求救信號的粗糙特質在人類進化上有重大意義，讓人們更有效地應對危機，在惡劣的環境下生存。這方面的研究將會讓我們更能了解溝通能力的進化過程，以及腦部如何進化以應付恐懼。以相類手段研究動物的叫聲，也會讓我們知道這特性如何呈現在不同的物種中。

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Bruises are painful, none-too-memorable souvenirs left from fresh misfortunes, which manifest in a range of colours that transform over time. They begin from the 'freshly minted red' to the 'unnaturally rich purple', and finally to the 'healing jaundice yellow'. Most commonly arising in response to blunt force that traumatises the skin's underlying tissues and blood vessels, bruises form beneath the skin's surface due to blood leakage from damaged vessels that settles into the surrounding interstitial fluid. Investigating the changing colours of bruises has the potential to reveal information on the nature of the incident and the age of the bruise.

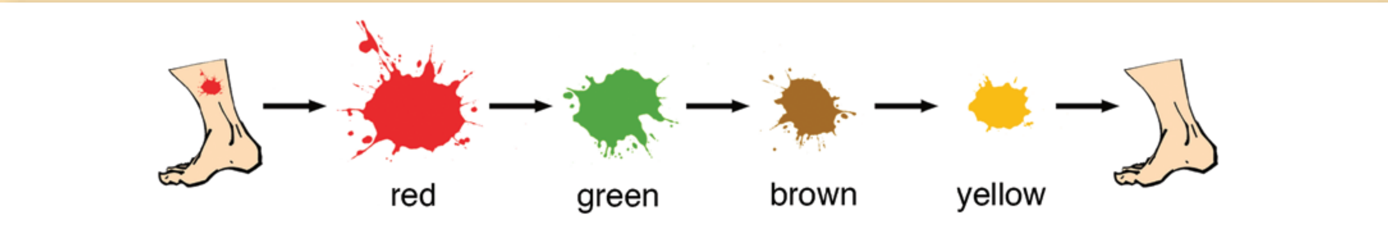
What gives rise to the tentative colours of bruises is primarily haemoglobin, a dominant chromophore that plays a role in determining the colour of our skin. The initial red colour is given off by haemoglobin itself. The body then produces an inflammatory reaction in response to the spillage, to remove blood from the interstitial tissues. Macrophages phagocytose red blood cells to degrade haemoglobin into biliverdin, a green compound, as well as carbon monoxide and iron. The iron then forms haemosiderin with the ferritin protein, creating a brown colour. Lastly, biliverdin is rapidly metabolised to form bilirubin, which is yellow in colour, signifying a bruise that is about to disappear [1].

In criminal cases involving child abuse or assault, it is common for forensic experts to estimate the age of bruises based on the colour. Since the conclusions of such analyses have the potential to influence the outcome of convictions, several studies were conducted on determining the accuracy of these visual estimations. In 2010, a simple study involved 11 participants voluntarily inflicting bruises on themselves, all in the name of science! Using a pump, suction was applied to the skin to produce a uniform circular bruise on each subject. Photographs of the bruise were taken daily, and 15 forensic experts were asked to estimate the age of the bruise and arrange the photographs in chronological order.

It was found that as the actual age of the bruise increased, the accuracy of the estimations decreased [1]. In addition, many conclusions made by the observers were extreme outliers. Estimation accuracy was highest for freshly inflicted bruises, between 0 to 12 hours, but misjudgements occurred in every time group. The results concluded that visual assessment of photographs of bruises is an unreliable method for estimating when bruises were inflicted.

What about speeding up the healing process of a bruise? Popular home remedies include unceremoniously slapping a piece of raw steak on a shiner or repeatedly rolling an egg on a stubborn bruise among other outlandish claims. Unsurprisingly, the efficacy of steak masks is a myth. What actually helps is the cold factor of the frozen steak, since cold temperatures constrict blood vessels and reduce inflammation or swelling. In fact, placing raw meat on an injured area is highly unadvised due to potentially dangerous bacterial infections. Frozen steak can also cause freeze injury around the wound. Applying an ice pack would be a healthy alternative that gets the job done.

Bruises are unsightly, painful and largely unavoidable, but they are the body's natural process of healing. Whereas estimation of the chronological age of a bruise based on its appearance is not scientific, different colours of the bruise divulge the processes involved during its recovery. Scientists are racing to develop a reliable system to provide more accurate estimations of the chronological age of bruising.



By Jacqueline Aw 歐梅婷

瘀痕是因新近遇到不幸，留下來的痛苦印記，會隨著時間推移而轉變顏色，從起初的「鮮紅」到「詭異濃鬱的紫」，最後呈現標誌著癒合期的「黃膽色」。最常見的成因是由鈍力引起皮膚深層組織和血管損傷，血液從受損血管滲漏並積聚在周圍間質液，形成瘀痕。分析這些顏色的變化，或會揭示事故性質和發生時間。

瘀痕的不同顏色主要是源於血紅蛋白，一種影響我們膚色的發色團。初始的紅色是來自血紅蛋白本身。我們的身體因應血液滲漏而啓動發炎過程，以移除間質組織中的積血。首先，巨噬細胞吞噬紅細胞，將血紅蛋白降解成綠色的膽綠素，以及一氧化碳和鐵。所得的鐵質跟鐵蛋白結合而成血鐵黃素，帶來褐色。經過快速代謝後，膽綠素又會變成黃色的膽紅素，到此瘀痕也就差不多消退了[1]。

在涉及虐待或毆打兒童的刑事案件中，法醫專家常常用瘀痕的顏色來推斷受傷時間。由於這類分析結果有可能影響裁決，所以有研究評估這些目測是否準確。在2010年，有11人參加了一個簡單的研究，爲了科學而自行以抽吸泵在皮膚上造成均稱圓形的瘀痕。研究人員每日為瘀痕拍照，然後讓15位法醫專家來估計受傷時間，並將照片按時間先後排序。

結果發現受傷時間越長，專家判斷的準確度越低[1]，而且提出的許多結論都是嚴重偏離實況。準確度最高的是在12小時之內造成的新瘀痕，不過，每一時間組都有誤判。此研究得出的結論是：以視覺評估瘀痕照片而得出的受傷時間並不可靠。

那麼怎樣能夠加快癒合的過程呢？常見的法寶不乏種種妙想，包括毫不客氣地以生牛排拍打黑眼圈，又或是將雞蛋放在頑固瘀痕上來回滾壓。牛排的作用其實只是神話。真正有效的是牛排的寒氣，因為低溫可以收縮血管，減少炎癥或腫脹。實際上，把生肉放在傷口是不明智的，因為可能會招致危險的細菌感染。冰凍牛排還有可能在傷口附近造成凍害。以冰袋替代較為穩妥。

瘀痕確是不堪入目、疼痛，並且很難避免，卻代表著人體自愈的自然過程。憑藉外觀來推算瘀傷發生的時間，固然是不科學的。不過，從瘀痕不同的顏色可以知道與癒合有關的種種過程。科學家現正努力開發更可靠的系統，以求準確地評估瘀傷發生的時間。

References

[1] Pilling, M. L., Vanezis, P., Perrett, D., Johnston, A. (2010). Visual assessment of the timing of bruising by forensic experts. *Journal of Forensic and Legal Medicine*. DOI: 10.1016/j.jflm. Retrieved from *http://www.sciencedirect.com/science/article/pii/S1752928X09001772*

Increasing hygiene concerns have sparked consumer trends in preferring antibacterial soaps over more traditional ones. The extra label provides additional reassurances of protecting us from illnesses brought about by harmful microbes, and thus, gives us a peace of mind. However, do antibacterial soaps truly outdo their counterparts, in terms of eliminating pathogens? Whether these antibacterial soaps are as effective as manufacturers claim them to be deserves a closer examination in this flu season. Let's begin with a look into soap's chemical structure and functions.

Soaps fall under the category of detergents, referring to substances with cleaning abilities in dilute solutions. Soap molecules resemble tadpoles, with a hydrophilic (water-loving) head and a hydrophobic (water-hating) tail. In the presence of lipids, the tadpole tails interact with and enclose the lipids, while the heads irradiate outward, interacting with the aqueous medium. These spherical envelopes formed by the tadpole-like detergent molecules are known as micelles. Soap's amphiphilic property allows it to solvate the phospholipid membranes of bacteria with its hydrophilic head, and the hydrophobic tail allows the enclosed bacteria to be easily lysed. In other words, all soaps are 'antibacterial'. Virus capsids, however, are composed of proteins instead of fatty acids. Given that proteins have relatively low affinity toward the hydrophobic tails of soap molecules, viruses are less vulnerable to be lysed by soap.

Antibacterial soaps (for lack of a better term), on the other hand, often contain an active ingredient called triclosan, differentiating it from traditional soaps. Originally used exclusively in hospital settings, triclosan is now found in 75% of liquid antibacterial soaps and a slew of other products such as wet wipes, hand gels, and even mattresses. Its chemically stable structure allows it to be heated to high temperatures, making it a suitable addition to various plastic materials. Triclosan works by reacting with amino acid residues at the enzyme active sites to form ternary complexes that mimic natural substrates. These mimics are considered abnormal enzyme-substrate complex which in turn inhibit the bacterial fatty acid's biosynthetic pathway, leading to the collapse of a series of metabolic reactions vital to the bacteria's survival through protein and lipid synthesis.

Studies have shown that traditional soap and water remove approximately 99.4% of the bacteria on our hands. Soaps containing triclosan raise that percentage to 99.6% - not significantly different by any means. In fact, the addition of triclosan leads to the potentially bigger problem of antibiotic resistance. Since triclosan is present in trace amounts in commercial detergents, there have been concerns that the strongest 0.4% of bacteria which are not killed would mutate, and develop cross-resistance to not just triclosan, but other antibiotics as well. The good news is that while signs of resistance were found in the laboratory, it has yet to be observed in the environment for such an experiment would be difficult to execute.

Despite the fact that antibacterial soaps have a slight edge over traditional ones, the question remains whether they add much to the promotion of hygiene. Cold-like symptoms are also more often caused by viruses than bacteria, and soaps in general are less effective in eradicating viruses. While the use of antibacterial soaps has its benefits for people with compromised immune systems where that extra edge is necessary, most homes should be adequately equipped against pathogens with traditional soaps. After all, good hygiene is really brought about by regular handwashing rather than specialised soaps.

A Glimpse into TRICLOSAN 淺談「三氯生」

By
Man Hing Wong 黃雯馨

隨著人們的衛生意識不斷地提高，消費者傾向選擇殺菌肥皂，以取代傳統產品。有了「殺菌」的標籤，似乎能夠抵禦細菌的侵襲，提供多一重的健康保障，讓我們感到安心。但是，這些殺菌肥皂是否真能比普通肥皂更有效地殺滅病原體？在這流感季節，我們好好審視生產商所聲稱的殺菌效能是否屬實。首先我們要了解一下肥皂的化學結構以及功能。

肥皂是清潔劑的一種，在稀溶液中有去污作用。肥皂分子的結構就像蝌蚪：擁有「親水性」的頭部以及「親脂性」的尾巴。這些「尾巴」會黏附並包圍油脂，讓「頭部」外露與水性介質接觸，形成被稱為「膠束」的球狀結構。這種「雙親性」特點讓肥皂分子可以其親脂性「尾巴」溶解細菌的磷脂膜，再用親水性「頭部」讓細菌更易被裂解。簡言之，所有肥皂都具有殺菌功能。不過，病毒的衣殼是由蛋白質而非脂肪酸所組成，與親脂性「尾巴」的親和力較低，也就較難被肥皂分解。

有別於傳統肥皂，「殺菌肥皂」(姑且這樣叫)一般含有活性成份「二氯苯氧氯酚」，俗稱「三氯生」。三氯生最初只作醫療用途，發展至今已被廣泛使用，有75%的潔手液含有三氯生，其他產品包括清潔濕巾、潔手凝膠，甚至是床褥。三氯生的化學結構穩定，且耐高溫，適合作為塑膠添加劑。三氯生的殺菌機理是通過和酶活性位點上的氨基酸殘基產生化學反應，形成模擬自然酶底物的三元絡合物。這些異常的酶-底物複合物會抑制細菌脂肪酸生物合成途徑，從而破壞一系列關係細菌存亡的重要代謝反應。

研究顯示，傳統肥皂跟水可以去除我們手上約99.4%的細菌，含有三氯生的肥皂可將比例提高至99.6% — 差別其實不大。事實上，三氯生可能會導致細菌產生抗藥性，觸發更嚴重的問題。三氯生在市面上的清潔劑中含量極少，不能殺死那最強的0.4%細菌。這些細菌可能會產生突變，對三氯生及其他抗生素表現出抗藥性。在實驗室內已發現到抗藥性的跡象。實驗室外則由於執行方面的限制，尚未有這方面的觀察。

縱使殺菌肥皂比傳統肥皂略勝一籌，但仍有疑問這類產品是否可以大幅改善衛生。傷風感冒的症狀多數是由病毒而非細菌所引發，一般而言，肥皂並不能有效消除病毒。對於免疫系統受損的人，殺菌肥皂的確可以提供必要的額外保護；但是普通家庭只須傳統肥皂便足可抵禦病原體。總言之，勤洗手才是保持良好衛生的不二法門，無須以特色肥皂取代。

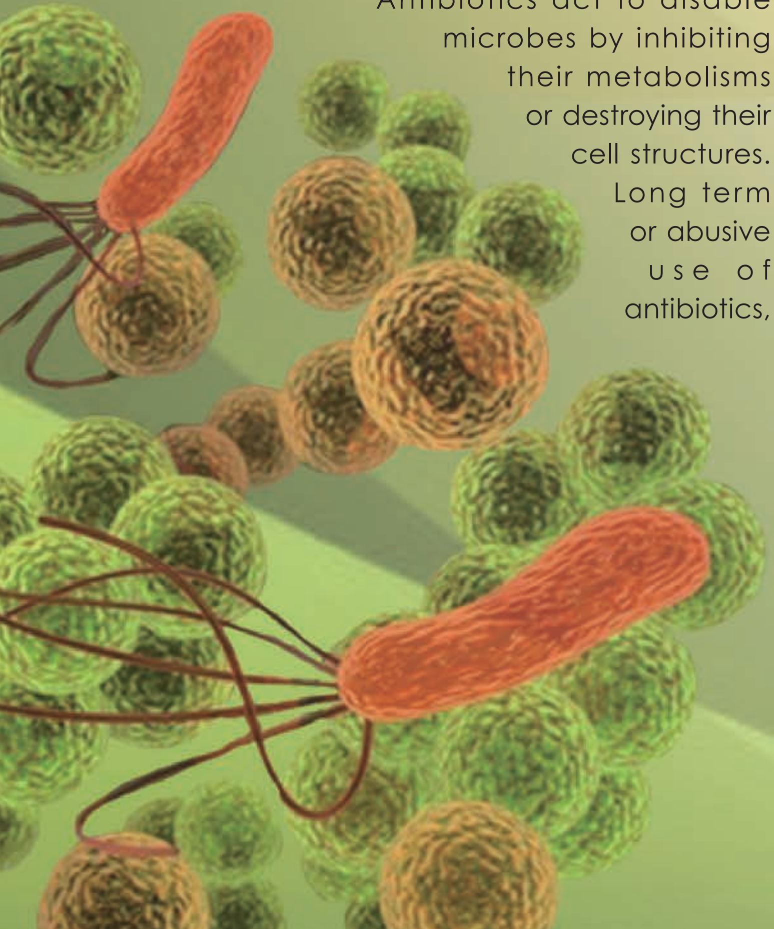
Further Reading

[1] Schweizer, H. P. Triclosan: a widely used biocide and its link to antibiotics (2001). Fems Microbiology Letters, Elsevier. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1574-6968.2001.tb10772.x/pdf.

Battling diseases and understanding the mechanisms of harmful pathogens have been an upward struggle since the discovery of penicillin in 1928, marking the beginning of the era of antibiotics. With the contention of drug resistance, however, the pressure is back on to break the enigma of pathogens and develop new drugs to tackle ever-evolving bacteria. **Prof. Bonnie Bassler**'s Shaw Prize winning research in anti-quorum-sensing therapy is one such weapon to tackle this ongoing problem.

Quorom sensing refers to the form of communication between cells or microorganisms. Cells produce hormone-like chemicals known as "signals" or "autoinducers" that can be picked up by other microorganisms, containing information such as the number of other microbes in their immediate surroundings. For example, *Vibrio fischerici* is known for its bioluminescence and only glows when it detects enough of its compeers in its proximity to increase virulence, and conserves energy in the absence of its own kind. This is how bacteria have communicated for billions of years, and act collectively for the betterment of its species. Prof. Bassler and her team have managed to develop molecules that disrupt quorum-sensing by blocking signal receptors. In failing to recognise the presence of compeers, bacteria pathogenicity is reduced.

Antibiotics act to disable microbes by inhibiting their metabolisms or destroying their cell structures. Long term or abusive use of antibiotics, however, could lead to bacterial drug resistance, particularly when the dosage is inadequate to eliminate bacteria. Each new antibiotic takes many years to research and develop into fruition, making this a very difficult problem to tackle when bacteria can develop drug resistance in a much shorter time. Anti-quorum sensing equips us with an entirely new method of battling diseases.



"Since an anti-quorum-sensing strategy would alter bacterial behaviour, rather than outright kill bacteria or slow their growth, resistance would come about more slowly than with traditional anti-bacterials," Prof. Bassler pointed out.

In other words, when bacteria are not being killed, evolutionary pressure to survive is less pertinent and buys the immune system extra time to eliminate them. This innovative strategy is without a doubt "a promising route to controlling bacteria".

Quorum Sensing with Prof. Bonnie Bassler and Prof. Peter Greenberg

人類在1928年發現了盤尼西林，開啟了抗生素時代，自此奮力與疾病作戰，探索病原體的致病機制。隨著抗藥性的出現，我們面臨壓力要破解關於病原體的種種謎團，以及開發新藥以應付不斷演變的細菌。**邦妮・巴斯勒教授**所研發的「抗群體感應療法」，正好有助解決這個長期存在的問題，為此獲授予邵逸夫獎。

「群體感應」是指細胞或微生物之間的溝通。細胞會製造一些稱為「信號」或「自體誘導物」的化學物，作用與荷爾蒙類似，可被其它微生物探測，傳送不同信息如在周圍環境中微生物的數量。以會發光的鯢弧菌為例，它們只在身邊有足夠的同伴時才會發光，缺乏同伴時就會節省能量。過去數十億年來，細菌都是這樣溝通，並為整體物種的利益而集體行動。巴斯勒教授的團隊研發了阻斷信號受體的分子，

The potential of anti-quorum-sensing technology is two-fold. Prof. Bassler's ground-breaking discovery has provided "a needed proof-of-principle" that quorum sensing technology can be put into practice and be used to develop novel drugs in the war against bacteria. The unfortunate truth is that bacteria out-evolve current antibiotics, but her research is not limited to drug development. She suggests that pro-quorum-sensing (which is the opposite of anti-quorum-sensing) could be used to spur bacterial behaviours that could be applied to industrial, agricultural or environmental uses.

In addition to being a world-renowned scientist, Prof. Bassler is also well-known for her regular appearances at TED talks to promote the social responsibilities of scientists. A firm believer that scientists bear the responsibility of promoting their research to the layman, she makes sure that her research on quorum sensing is both vivid and attainable. Watch one of her TED talks at *https://www.youtube.com/watch?v=KXWurAmtf78!*

2015年度
邵逸夫生命科學與醫學獎 得主—
邦妮·巴斯勒教授和彼德·格林伯格教授

By Andy Cheung 張文康

可以擾亂群體感應，令細菌不能探測到同伴的存在，其致病能力也就大大降低。

抗生素是通過抑制微生物的代謝，或破壞細胞結構以發揮效用。不過，長期濫用抗生素可能會導致細菌抗藥性，尤其是當劑量不足以徹底消除細菌時。每種新抗生素都要經歷漫長的研究開發過程才可投入廣泛使用，相反，細菌只需很短時間就可以發展出抗藥性，這是一個非常棘手的問題。抗群體感應則以全新的方法對抗細菌。巴斯勒教授指出：「抗群體感應策略影響了細菌的行為，而不是直接殺死它們或延緩其成長。因此相對於傳統的抗菌藥物，細菌的抵抗會來得較慢。」換句話說，當細菌不用面對滅亡時，求生的演化壓力就會減弱，容許我們的免疫系統有額外時間去消滅它們。如巴斯勒教授所言，這創新策略無疑是「為控制細菌提供了新路徑以及可能性。」

抗群體感應技術的應用潛力有兩方面。貝斯勒教授的突破性研究提供了概念性驗證，說明群體感應技術是可以付諸實踐，並且用於開發新藥對抗細菌。現有的抗生素實已不足以應付不斷演變的細菌。不僅如此，巴斯勒教授認為「親群體感應」(即是抗群體感應的反面)也可用於工業、農業或環境等領域，鼓勵相關的細菌行為。

巴斯勒教授不僅是舉世知名的科學家，她也經常在TED平臺演說，宣揚科學家的社會責任。她堅信科學家有責任向大眾推廣自已的研究。讀者可到https://www.youtube.com/watch?v=KXWurAmtf78看看巴斯勒教授如何把高深的群體感應技術解釋得生動易明。

Along with Prof. Bonnie Bassler, the 2015 Life Science and Medicine Shaw Prize was shared by **Prof. E. Peter Greenberg**, who first coined the term "quorum sensing" and in parallel, elucidated the mechanism and interference with quorum sensing signals – the chemicals that microorganisms use to communicate among each other. Prior to his research, microbiologists generally did not accept the notion of bacterial communication and it was believed that each bacterium behaved as an independent cell. Prof. Greenberg is currently a professor at the University of Washington.

In a bacterial community, individual cells release chemicals to communicate with one another. Detecting the concentration of specific chemicals to determine the statuses or the number of its fellows provides grounds for cell-to-cell co-operation. In a community of *Pseudomonas aeruginosa*, individuals are able to communicate through a "chemical language" to coordinate aggregate motion.

However, within the bacterial community, "cheaters" exist. These cheaters do not contribute but benefit from the goods produced by the co-operators, and thus possess a fitness advantage because they do not pay the cost of contribution. "We have used *Pseudomonas* to investigate quorum sensing to understand ways in which populations can control cheaters and stabilise cooperation." By controlling the concentration of specific chemicals present, Prof. Greenberg and his team have managed to disrupt the anti-cheater mechanism. In doing this, individual bacteria fail to recognise whether its own kind are growing or shrinking in numbers. As a result, their

Quorum Sensing with Prof. Bonnie Bassler and Prof. Peter Greenberg

除了巴斯勒教授之外，一同奪得2015年度邵逸夫生命科學與醫學獎的還有**彼德．格林伯格教授**，以表揚他成功闡述微生物通過化學物溝通的機制以及干擾效應。「群體感應」一詞就是由格林伯格教授提出的。在此之前，微生物學界普遍認為細菌都是獨立行事，不能互通資訊。格林伯格現為美國華盛頓大學的教授。

在細菌群落中，個別細胞會釋放化學物和同伴溝通。與此同時，它們也會探測特定化學物的濃度，以判斷鄰近細胞的狀態和數量，從而做到互相協同。以綠膿桿菌群落為例，成員就是通過「化學語言」 而協調聚集。

不過，菌落中也會有「騙子」。它們不會為群體利益作出貢獻，卻享受集體成果。因為無須付出，這些「騙子」擁有演化優勢。「我們研究綠膿桿菌，從而探索群體感應機制如何限制騙子的數目，以及維持穩定的合作關係。」透過調控特定化學物的濃度，格林伯格教授的團隊成功擾亂了細菌

numbers will shrink. With an increase in cheaters, ultimately every individual suffers, leading to what he calls the "Tragedy of the Commons".

Without too many obstacles in their research, thanks to predecessors Anitol Eberhard and Ken Nealson who monumentally found the first member of this class, Prof. Greenberg and his team were able to identify additional anti-quorum sensing compounds. "The greatest problem is always constructing strains of bacteria that we can use as bioreporters to measure the signals". With work beginning on *Vibrio fischeri* initially and then *P. aeruginosa*, as well as a number of uncovered signals in other bacteria, Prof. Greenberg stresses the importance of investigating diverse systems and the discrepancies of which bacteria use quorum sensing to help us understand bacterial cell communication better in general.

Applications are wide and varied once we understand the mechanism of quorum sensing in plants and animals. Chinese fish farms have already begun to adopt anti-quorum sensing technologies to fight against diseases among fish. In South Korea, water filtration plants have implemented similar technologies to combat the growth of unwanted biofilm and extend the life of filters. Quorum-sensing drugs are an unexplored avenue, but its implications are endless once the ball gets rolling. Research has shown that certain foods such as garlic and ginseng may contain active ingredients that are natural quorum sensing inhibitors. Prof. Greenberg pointed out that "The trouble is what to do from there [understanding quorum sensing] ... quorum sensing signals can have utility in the biomanufacturing world to regulate production of whatever kind of product one would like to make biologically".

2015年度邵逸夫生命科學與醫學獎 得主 —
邦妮·巴斯勒教授和彼德·格林伯格教授

的反騙子機制。個別細菌因而未能知道同類數目是增多還是萎縮，結果是數目減少。騙子多了，最終每個細菌都會受害，這就是格林伯格教授所說的「公地悲劇」。

第一個抗群體感應化合物是由Anitol Eberhard和Ken Nealson發現的。有了這個線索，格林伯格教授的團隊沒有碰到太多障礙，就發現了更多的抗群體感應化合物。「最大的困難是要構建可以探測特定信號的生物報告菌株。」格林伯格教授先後研究了鯢弧菌、綠膿桿菌和其他細菌的不同信號，強調必須要研究多個系統和不同的群體感應，才能對細菌溝通有一個較全面的理解。

植物和動物細胞的群體感應機制破解後，就可衍生出廣泛不同的應用。中國的養殖場已經使用抗群體感應技術來控制魚類疾病；某些南韓的濾水廠也利用類似科技來防止細菌形成菌膜，以延長濾膜壽命。現在還未有研發抗群體感應藥物，但可以預見這方面的應用將帶來無限可能。已有研究指出，某些食物如大蒜、人參的活性成分可能正是天然的群體感應抑製劑。格林伯格教授指出：「讓人傷腦筋的是[破解了群體感應機制]之後要做些什麼......將群體感應信號應用於生物製造，可以調控生產出任何人類想要的生物產品。」

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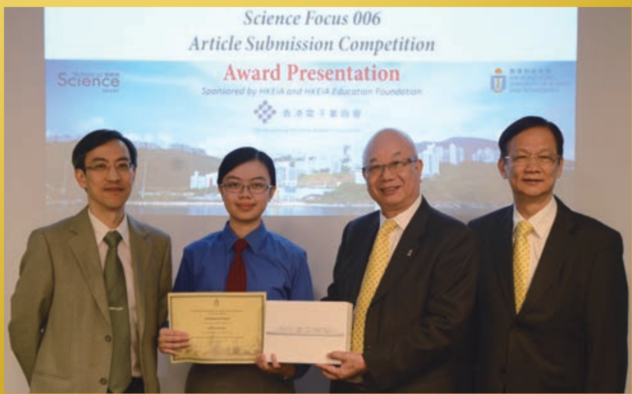

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